State of California
The California Natural Resources Agency
DEPARTMENT OF WATER RESOURCES
Division of Statewide Integrated Water Management

ANALYSIS OF THE DEPARTMENT OF WATER RESOURCES VOLUNTEER CLIMATE COOPERATOR NETWORK

Memorandum Report

December 2012

State of California California Natural Resources Agency

M e m o r a n d u m

Date: 12/5/2012

To: John Andrew, Climate Change Program

Elissa Lynn, Climate Change Program

Mike Anderson, California State Climatologist

From: Aaron Cuthbertson
Division of Statewide Integrated Water Management
Department of Water Resources

Subject: Analysis of DWR's Volunteer Climate Cooperator Network

John, Elissa, and Mike:
The following report discusses the current state of DWR's Volunteer Climate Cooperator Network, and makes suggestions for the future of the program.

EXECUTIVE SUMMARY

BACKGROUND

- The Department of Water Resources (DWR) maintains a statewide network of volunteer weather observers who collect daily temperature and precipitation data.
- The network was established in the 1950's, but has been in decline since the early 1990's, and now has the lowest number of participants since its inception.
- Currently there are about 80 volunteers remaining in the program.
- The program has not done active recruiting of new volunteers in at least 20 years.
- The program has not adequately supported the volunteers, especially in providing feedback, training, and guidance in collecting data and maintaining data collection equipment since the 1990s.
- The program data are stored in data silos at region offices.
- There is no formal means of reviewing, analyzing, or disseminating the collected data.
- Each region office has large amounts of climate data in paper archives that may not yet have been digitally archived
- DWR also maintains a separate volunteer network for snow surveys, which receives support under the Division of Flood Management (DFM).

DECISION FACTORS

- A decision whether to continue collecting climate data from volunteers under this program is needed at this time for the following reasons:
    - Volunteer efforts over long periods of time should be properly honored
    - Program data is currently inaccessible, and needs to be made available to researchers
    - The program is in decline, both in terms of quantity of observers and potentially the quality of observations.
- Facilitating volunteers to join the CoCoRaHS incurs these estimated costs:
    - $5,550 in one-time costs, primarily to purchase CoCoRaHS-approved equipment for all volunteers in the program.
    - $4750 annually to maintain the program going forward, primarily for data entry assistance for those volunteers who cannot conduct online data entry.
- Alternatively, revitalizing the program by developing data management and dissemination in-house incurs these estimated costs:
    - $23,490 in one-time costs to shore up technology infrastructure and revise program manuals
    - Approximately $24,360 annually, the bulk of which would cover site visits, data entry and correspondence.

RECOMMENDATIONS

- Facilitate the migration of volunteers to the CoCoRaHS Network. Reasons:
    - Program Stability: CoCoRaHS is a growing, well-funded and well-managed program with a promising long-term outlook
    - Data input and management: CoCoRaHS already provides data management and web-based data entry; DWR would not have to support these functions in-house

    - QA/QC: CoCoRaHS conducts training, provides informational materials for improving data collection, and does some QA data review on input data
    - Data Dissemination: CoCoRaHS data is immediately available for use and easily obtained by volunteers and the general public via the web
    - Cost: Facilitating migration to CoCoRaHS is significantly cheaper both initially and annually than continuing to operate the program in-house
- Supply CoCoRaHS-approved rain gauges to volunteers that migrate to the CoCoRaHS Network.
- Continue to do data entry (but now into CoCoRaHS) for those volunteers who cannot or are resistant to doing their own web-based data entry.
- Whether or not the program is continued, the following additional steps are recommended:
    - Catalog existing climate data at the regional offices (including the volunteer network data and other project data) and plan for archival storage (This step is currently underway).
    - Promote cooperation between climate data collection programs within DWR to share knowledge and materials when possible.
    - Ensure that data collection continues into the future for 30 targeted sites considered especially valuable due to long periods of record and location.

CONTENTS

LIST OF FIGURES

FOREWORD BY DAN CAYAN, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UC SAN DIEGO

THE IMPORTANCE OF VOLUNTEER OBSERVERS IN MONITORING CALIFORNIA'S WEATHER AND CLIMATE

A regular stream of weather and hydrological observations is vital to California's planning, preparedness and hazard response. Monitoring our weather and climate is challenged by the broad extent and rugged landscapes in the State and the volatile weather and climate patterns that occur here. Achieving this requires a dense array of measurements, not only in low elevation highly populated locations, but also in higher elevation, sparsely populated settings that collect the major fraction of California's water supply and occasionally receive the heaviest precipitation that drives the State's flood flows.

Key aspects of what we know about climate variability, climate change and extreme events have been learned from measurements collected by volunteer observers. Presently, we find ourselves in the early phase of what looks to be an unprecedented shift in California's climate as global climate changes. Projected changes in precipitation do not appear straightforward--some climate models suggest lower annual totals, on average, but they also produce higher amounts in the most extreme storm events. We need more data, not less, to detect and understand these changes!

California depends upon a tier of different layers of measurements to guide and verify forecasts and to understand processes and changes. The set of manual surface observers might seem "low tech" and replaceable, but it underpins the data collected by more elaborate sensors—these high-end instruments are only selectively deployed and will remain that way because they are expensive to operate and maintain. New government-run monitoring programs are unlikely, so a continued effort to involve volunteers only makes sense.

Although the DWR volunteer network has decayed, it is encouraging to know that volunteer observing has not fallen out of fashion—in fact it looks to be very "hip". Several volunteer networks have grown, given some guidance and promotion. Across the State, the West and the nation, the viability of volunteer programs is evidenced by the rapidly developing Mesonet weather station network, the CoCoRaHS precipitation observer network, and the National Phenological network.

California's environmental awareness, progressive technical tradition and spirit of community provide the essential elements to rebuild the State's volunteer weather observers. Such a network is key to prediction and understanding, and at the same time a great program to involve local communities and to spread information.

HISTORICAL PERSPECTIVE BY JAMES GOODRIDGE, FORMER CALIFORNIA STATE CLIMATOLOGIST

The great flood of 1862 caught Californians by surprise. There were few physical measurements suggesting the possibility or cause of such a damaging storm. This event stressed the importance of collecting rainfall records from any available sources in-order to understand the frequency and magnitude of floods as well as the periodic severe droughts.

There were extensive weather records published in the early annual Transactions of the California State Agricultural Society. The first regular monthly publication of volunteer weather reports was apparently Monthly Bulletin of the California State Weather Service starting in 1891. This was the predecessor of the Climatological Data published continually since 1897, now by the National Climatic Data Center in Ashville NC. Climatological Data is treasured today for its historical continuity rather than its comprehensiveness.

The statewide office of the US Weather Bureau was transferred from Sacramento to San Francisco in time for the earthquake and fire of 1906. The state's weather record archive was lost in the fire. There were some water agencies that kept copies of their records. The Department still has some old records like the Pilarcitos station in San Mateo County with daily data from 1865. Some of the even older records were compiled by the Smithsonian Institution are archived at the National Archives.

The State Engineer published of PHYSICAL DATA AND STATISTICS OF CALIFORNIA in 1884. It was a comprehensive compilation of California rain records. Another major compilation of all available rainfall records was the Greely report IRRIGATION AND WATER STORAGE IN THE ARID REGIONS, The Executive Documents of the House of Representatives, Second Session of the Fifty-First Congress, Volume 88, 1891. This is a monthly summary of volunteer rain records up to 1890. The publication FLOW IN CALIFORNIA STREAMS by the Department of Public Works, Division of Engineering and Irrigation published in 1923 summarized thousands of volunteer rainfall records. It was followed and enhanced by WATER RESOURCES OF CALIFORNIA, Bulletin No. 1 of the State Water Resources Board in 1951. Bulletin 1 was an encyclopedic type listing of many thousands of volunteer rainfall records that were used in forming the State Water Plan of 1963. All but perhaps a few dozen were from volunteer weather observers. The 1884 and 1924 State water plans were also based on records of volunteer weather observers.

Obtaining timely operational rain reports was at one time more difficult. Telephone and mail and limited Teletype reports were the rainfall data sources of sixty years ago. The telephone gave way to the Internet as automated observing systems became functional for observing rainfall in real time. These weather and flood forecasting applications were mainly horizontal in time for use in the current forecast. Another audience vertical in time will depend on historic continuity for long range planning. There are very few precipitation stations devoted to infrastructure design. Applications of carefully documented and properly archived data are many. These will be the histories needed to evaluate climate change and plan response as well as culvert sizing and flood control requirements.

Automated weather observing systems in real time are a glitzy part of weather data collection. Future record needs depend on adequate archiving automated systems as well as manual records. Some rain data collection networks designed for flood warning and costing millions are routinely discarded at the end of the flood season without being archived. The manual observations fill the historic need for continuity of our oldest records. These records are needed to evaluate long-term trends and to verify the reliability of unattended systems by personal observations. The longer records are needed to understand the relative importance of 5 inches of rain in one day.

There are several networks of weather stations that until recently lacked provisions for archiving records. These ad hoc applications include flight weather, weather forecasting, flood protection, irrigation planning and fire hazard evaluation. The data networks with real time weather data include the California Irrigation Management Information System (CIMIS), California Data Exchange Center (CDEC), Snotel and the Remote Automated Weather System (RAWS). These networks all dedicated to single objectives. Adequate archiving to create an engineering and planning archive of rainfall data has been undertaken by the Western Region Climate Center (WRCC).

Responsibility for building codes and public safety falls ultimately on county government. The larger Counties and Cities of California have assumed responsibility for collecting and archiving rainfall data in their jurisdictions as the data local needs exceed those of state or federal governments.

Applications of rain data are many as an example the cost of highway culverts increases with the fourth power of the diameter and Caltrans provides a once in a hundred years level of flood protection. Over sizing is very costly and under-sizing exposes builders to liability for under protection. Typical engineering decisions include the work of legislators and administrators who determine the acceptable level of risk in construction of projects. The Division of Safety of Dams has a much higher acceptable risk tolerance depending on if the downstream risk is to prairie dogs or people. In general a rainfall with a 1000-year return period is assumed to be an act of God rather than a fault of an upstream landowner.

Clearly observing and recording physical data on the world is science at its most fundamental form. The resulting records are the key to understanding the workings of climate variation, water supply and flooding and the key to intelligent decision-making. The diligent people who measured and recorded their observations have made progress possible. It became clear that all of the water agencies local, state, federal as well as private were feeding of the same pool of rain records that volunteers have kindly and generously shared. It is also crystal clear that the main beneficiaries of diligent record keeping are future generations.

ACKNOWLEDGEMENTS

This report draws from and builds upon the initial research into DWR climate data sources conducted by Adam Henderson, Northern Region Office, and the advice and guidance of Dr. Michael Anderson, CA State Climatologist and James Goodridge, former CA State Climatologist.

The report was completed with the extensive assistance and guidance of many other individuals, particularly Northern Region Staff: Peter Coombe, Pat Parsons and Todd Flakus; North Central Region staff Erin Chappell and Lana Graber, South Central Region staff Michelle Selmon, Jennifer Morales, and Michael McGinnis, Southern Region staff person Lauma Jurkevics, DWR Climate Change program staff John Andrew and Elissa Lynn, and Division of Statewide Integrated Water Management Statewide Data Program staff Greg Smith and Eric Senter.

INTRODUCTION

The purpose of this report is to describe DWR's volunteer climate data collection (VCCN) program in detail, place the program in context with other climate data collection efforts within DWR and the State, and provide a framework for a decision on whether to continue with volunteer data collection.

Since the 1950's, The California Department of Water Resources (DWR) has overseen a volunteer program for the collection of climate data, primarily daily precipitation and temperature minimums and maximums, called the Volunteer Climate Cooperator Network (VCCN). At the onset of the program, data for certain stations that had been collected by other entities was incorporated, so the program has data going back to around 1900 for some sites. The program was very active from 1960-1980, but has suffered from attrition of volunteers and a lack of recruitment of new volunteers since about 1990, and is now at risk for becoming defunct through continued attrition.

The Division of Flood Management's California Cooperative Snow Surveys Program (CCSS) also gathers climate data from a variety of sources including data from just a few VCCN volunteers. While the CCSS and the VCCN are separate programs, there are areas where they could benefit from cooperation, specifically in producing and distributing equipment recommendations and operating procedure manuals.

DWR's Northern, North Central, and South Central region offices have historically handled the volunteer program in their respective regions. A volunteer program was never implemented by the Southern region office. The region offices have different procedures for maintaining the volunteers and processing the resulting data. Rather than one centralized statewide volunteer program, this volunteer program is better described as a set of similar but separate regional volunteer programs. This presents problems for standardization, archiving and dissemination of the data.

This report serves as a decision point: should the department continue to collect volunteer climate data? If so, how will the department support this activity? If not, how will the department use secondary information to address the need for data for climate tracking, and studies of hydrology and flooding?

DESCRIPTON OF DWR'S VOLUNTEER CLIMATE COOPERATOR NETWORK (VCCN)

ANALYSIS PROCEDURES

The North Central Region Office (NCRO) and the North Region Office (NRO) maintain databases for the volunteer network. Data from the NRO and NCRO databases was used for the analysis of the network. Data for these volunteers was readily accessible and easily analyzed, and this paper primarily focuses on the North Central Region (NCR) and Northern Region (NR) volunteer stations[1]. Information on the South Central Region (SCR) volunteer program was obtained by examining Excel spreadsheets and physical files. This information was less complete, and more difficult to analyze, so the analysis of SCR volunteers is not complete. However, it is reasonable to presume that general findings for NRO and NCRO may apply to the SCR stations as well. The volunteer program was not implemented by the Southern Region Office (SRO).

In addition to the analysis of region office databases, region offices were visited and interviews with region office staff were conducted.

HISTORY

Volunteer weather observations began in California at least as early as the mid 1800's. Compilations of volunteer weather observations were published in the late 1800's by the US Weather Bureau and what is now the National Climate Data Center. By the mid 1890's, volunteer weather observations were an important dataset used to calculate future water supplies and aid in irrigation planning, estimate groundwater recharge and the calculation of spillway and culvert sizing.

DWR's VCCN program, established as the department was created, is a direct outgrowth of this long tradition. In the years since the department was founded, new methods of obtaining weather information including automated telemetered weather stations, and web-based data entry and dissemination have increased the ease of collecting and obtaining weather information. At the same time, funding cuts and the rise of national and regional monitoring networks have contributed to a gradual decline in DWR's volunteer program.

PAST AND FUTURE PURPOSES OF PROGRAM

VCCN program data has been and continues to be collected by the network has value for current and future studies. VCCN network data is used in DWR Bulletin 195 (California Department of Water Resources, 1976) and its periodic data updates.

In addition to its use in Bulletin 195, the VCCN data could be used in future studies of climate variation in California. Climate variation is an increasingly important issue in California water management. The VCCN network data could be an important data source for DWR climate-tracking studies particularly because of the long period of record for many of the stations.

Another potential benefit of the VCCN program is outreach to the general public. Volunteers work in cooperation with DWR region staff, and the program helps to strengthen the bonds between DWR and local communities. An

[1] All data for NCRO and NRO VCCN sites comes from snapshots of the NCRO and NRO VCCN Databases maintained by NCRO and NRO respectively. The snapshots of these databases used for these analyses were obtained on 7/5/2011.

active and comprehensive volunteer network provides DWR the opportunity to support and encourage general public interest in water issues in California.

ACTIVE SITES

Figure 1 displays the number of active sites within the program by regional office. Note that prior to 1960, both NCRO and NRO databases were populated with the same set of data, so early data are duplicated in the NRO and NCRO databases. There is no long-term record of site activity over time (in electronic form) for SCR, and time constraints prevented construction of this resource, so only a current figure was used for SCR observers.

NRO and NCRO display significant drops in activity starting in 1990 and continuing to date. Current participation is at its lowest level since inception of the program in 1960. If current declines continue at present rates, the program could drop to almost no volunteers within 10 years.

There are about 120 sites that have had measurements within the last 6 years. However, many have dropped out since then. There are 90 that have recorded measurements since 2009. Based on rates of dropout, we estimate that there are at most 80 remaining, truly active stations at the time of this report.

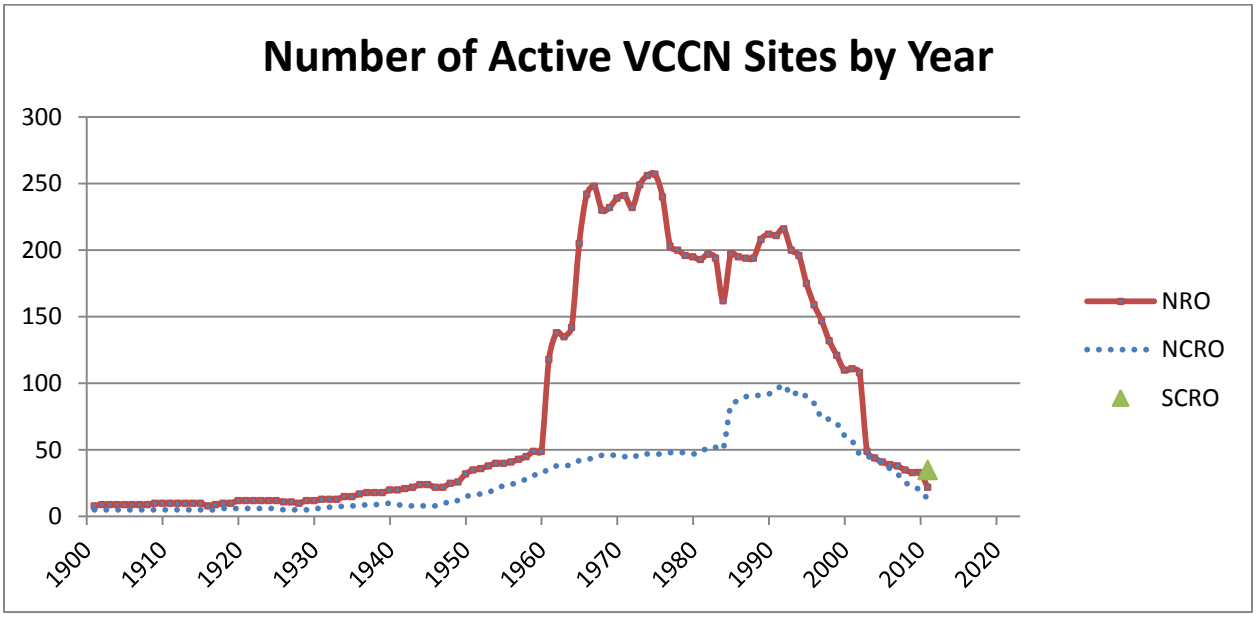


Figure 1: Active VCCN Sites by Year

NORTHERN REGION (NR):

The NRO database has 531 volunteer sites with precipitation data records, most of which are no longer active. Of these, 124 observers have reported data since 1/1/2000, but that number dropped to 41 since 1/1/2006, and only 33 since 1/1/2010. The number of active observers dropped by 73% from 2000 to 2010.

NRO recently conducted an informal survey of volunteers in the Northern region. The survey revealed that most of the remaining volunteers are entities such as fire departments, county offices, parks, and the like, and that a majority of citizen volunteers have fallen out of the program. Many of the remaining volunteers may already be reporting their data to other networks in addition to DWR (Flakus, 2012).

NORTH CENTRAL REGION (NCR):

The NCRO has 142 sites with precipitation data recorded since the beginning of the program. Most of these observers are no longer reporting, and the number of active volunteers is dropping rapidly. 66 observers have reported since 1/1/2000, but since 1/1/2006, only 36 volunteers have reported. Since 1/1/2010, only 20 have reported. Similar to program attrition in the Northern Region, the number of active volunteers in the North Central Region dropped by 70% from 2000 to 2010.

SOUTH CENTRAL REGION (SCR):

Data for SCR volunteers is kept in spreadsheets and physical files, and access and therefore analysis of these records has been more difficult, especially with respect to analyzing the history of the program.

There are about 30-35 active observers in the SCR, down from a high of "potentially hundreds of stations in the past" (Henderson, 2011), though, as indicated, the history of the program is not known to the degree that NR and NCR are known. Paper records and documents from SCRO are currently housed in the offices of the region's climate change staff.

SOUTHERN REGION (SR):

There are no records of a program, and existing staff don't have any knowledge or recollection of a volunteer program in the region. One theory is that the VCCN program in SR was discontinued in the 1980's when CIMIS was established (Henderson, 2011). However, it may be that the volunteer program was never implemented in the Southern region. What is certain is that there are no active volunteers in the Southern region at this time, and no records of past volunteer efforts have been found.

PERIOD OF RECORD

As we have seen, one consequence of the diminished support for the volunteer program over the last 20 years is the gradual reduction in numbers of sites in the program. However, a side effect is that most of the remaining sites within the program have long periods of record. Figure 2 and Figure 3 are histograms covering the period of record (in years) for active sites. The majority of active sites have at least 20 years of record, with several sites in both NR and NCR with 50 or more years of record.

The periods of record for SCR could not be calculated for this report, due to the method of storage in SCRO, and these numbers have not been obtained. Since recruitment has not occurred in SCR either since the 1990's or earlier, the remaining stations in SCR also have long periods of record.

COVERAGE

The VCCN stations are reasonably well distributed spatially, and there are stations at a variety of elevations, across the Northern, North Central and South Central regions. See Figure 5 for a map of the VCCN along with other monitoring stations.

DATA ARCHIVES

DIGITAL ARCHIVES

The VCCN Climate data is stored in separate digital archives in each region office. This makes access to the totality of the data very difficult. Data are stored in different formats as well: NCRO and NRO store the data in Microsoft Access databases with similar but not identical schema, and SCRO data are kept in Microsoft Excel spreadsheets.

A prototype centralized database application was previously created to house all the VCCN data from all regions, but more work needs to be done to complete this application and put it in production.

PAPER ARCHIVES

Northern, North Central, and South Central region offices all have large amounts of paper climate data stored in filing cabinets and boxes. North Central has 14 filing cabinets estimated to contain hundreds of thousands of monthly observer data sheets. It is not clear how much of this data has been entered into databases. Some of the data is from the VCCN program. Much of it is from other programs within and outside DWR. South Central and Northern regions have similar arrays of paper data in their offices. No catalog of these data exists, but efforts to catalog paper data at all the region offices are underway. This catalog will inform decisions on how to archive the data. See appendix B for a typical example of a historical data sheet from the program.

DATA DISSEMINATION

Dissemination of data is highly dependent on data storage, and since data is stored in different ways at each region office, data dissemination would be limited to separate programs administered by each region. There are no formal procedures for data dissemination at any regional office, and no systems in place for broadcasting to potential users the existence of the volunteer data. Northern Region does provide informal, ad-hoc support for data requests.

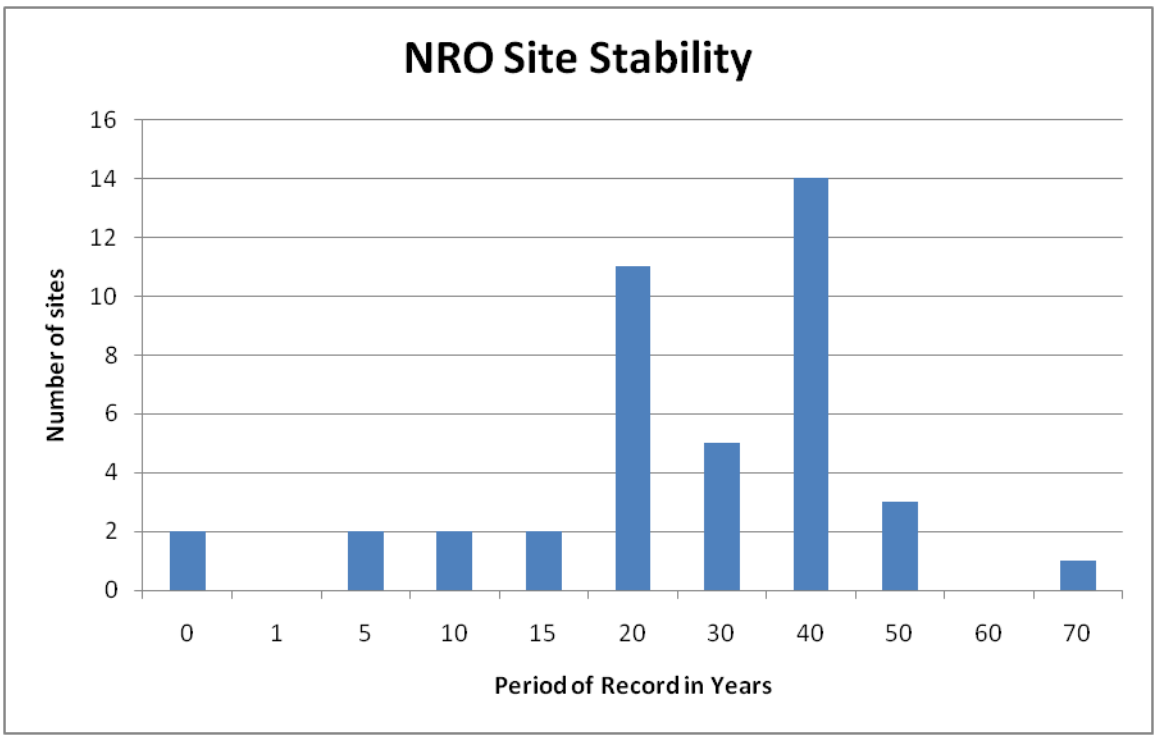


Figure 2: NRO VCCN Station Stability

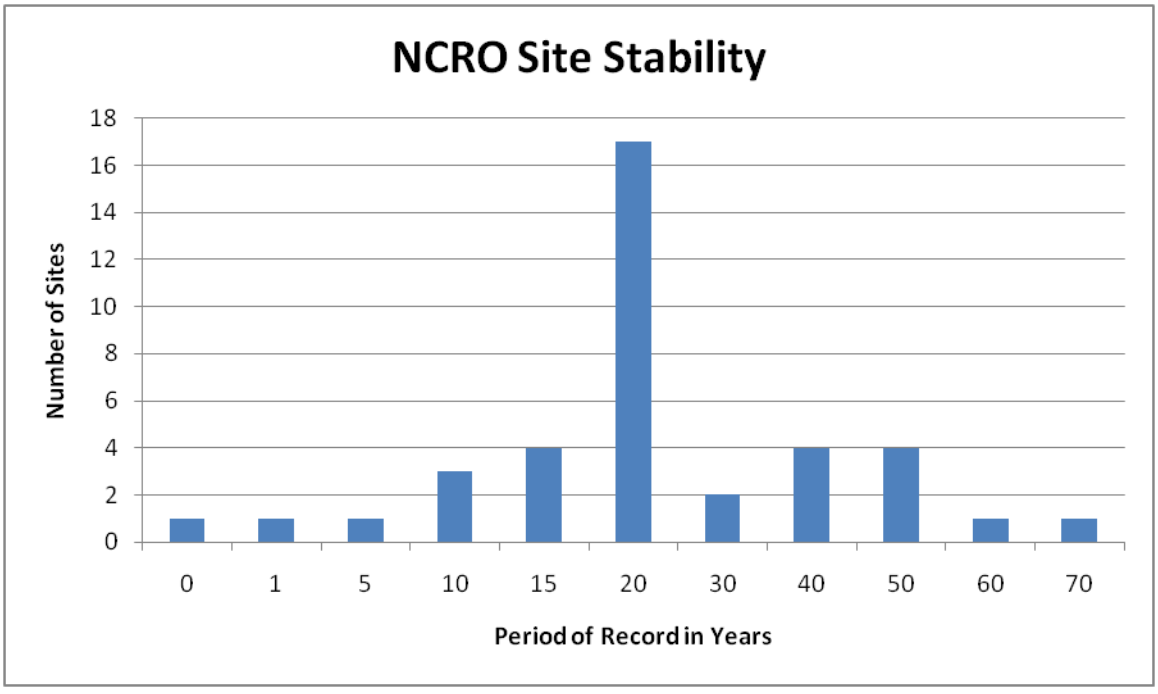


Figure 3: NCRO VCCN Station Stability

COMPARISON OF VCCN TO OTHER WEATHER DATA NETWORKS

OVERVIEW

Many other climate data collection networks are active in California. Networks include nationwide and international programs, statewide, regional and local programs. DWR also has a variety of programs that collect climate-related data for various purposes. The VCCN program is compared to these various climate data collection networks, and similarities and differences are discussed, to reveal relative strengths and weaknesses of the VCCN.

DESCRIPTIONS OF OTHER CLIMATE DATA COLLECTION NETWORKS

CLIMATE DATA COLLECTION NETWORKS WITHIN DWR

Many programs within DWR collect climate data manually and automatically for various purposes. Notable programs are described below. There may be other programs within DWR that conduct climate monitoring activities that are not listed here.

CALIFORNIA IRRIGATION MANAGEMENT INFORMATION SYSTEM (CIMIS)

The California Irrigation Management Information System (CIMIS), a program within the Office of Water Use Efficiency (OWUE) manages a network of approximately 120 automated weather stations in agricultural areas statewide. CIMIS collects climate data "to assist California's irrigators manage their water resources efficiently." (Department of Water Resources, Office of Water Use Efficiency, 2009)

CALIFORNIA COOPERATIVE SNOW SURVEY (CCSS)

The California Cooperative Snow Survey (CCSS) receives precipitation data from about 200 stations statewide. The snow survey uses this data to predict runoff in watersheds statewide. These runoff forecasts are then used to plan project and reservoir operations. The majority of data comes from nearly 115 locations in the Sierra Nevada or Shasta/Trinity mountain ranges with fairly even distribution from north to south. Roughly 60 locations are located along California's coastline, 35 within California's Central Valley, and nearly 20 in the South Lahontan or Colorado Desert regions. Snow survey data is stored in the California Data Exchange Center (CDEC). Figure 4 shows the locations of the CCSS stations in relation to the VCCN.

DIVISION OF OPERATIONS AND MAINTENANCE

The Division of Operations and Maintenance operates manual and automated monitoring of precipitation, air temperature, wind and pan evaporation at sites along the State Water Project. The data are used for a variety of purposes. A number of stations monitor the Feather River watershed which feeds Lake Oroville, the primary storage reservoir for the State Water Project. Other stations at reservoirs and along aqueducts are used to estimate precipitation gains and evaporation losses for project waters. Wind and temperature monitoring data are frequently used for analysis of water quality.

REGIONAL AND LOCAL CLIMATE DATA COLLECTION NETWORKS

Outside of DWR, there are many local and regional climate data networks operating throughout the state. For example, Santa Barbara County maintains a network of 50 automated weather monitoring stations (County of Santa Barbara, 2012). Los Angeles, Contra Costa, and Alameda Counties and many other counties and cities operate their own automated and/or manual measurement programs.

Other regional and local networks include those run by, flood control districts, irrigation districts, water agencies, and other utilities. These networks cumulatively provide thousands of manual and automated monitoring stations statewide.

NATIONAL AND INTERNATIONAL CLIMATE DATA COLLECTION NETWORKS

There are also national and international climate data collection efforts. Some notable networks in this category are the Community Collaborative Rainfall, Hail and Snow (CoCoRaHS), run by the Colorado Climate Center Cooperative Observer Program (COOP), run by the National Oceanic and Atmospheric Association's (NOAA) National Weather Service (NWS), and the Citizen Weather Observer Program (CWOP), a program that focuses on volunteer automated weather monitoring in near real time.

NATIONAL WEATHER SERVICE COOPERATIVE OBSERVER PROGRAM (COOP)

The NWS COOP is a network of about 11,000 volunteer observers nationwide. NWS staff installs and maintain monitoring equipment on volunteers' property, and the volunteer observer conducts daily monitoring of precipitation, temperature, and in many cases other parameters such as evaporation and soil temperature.

The purpose of COOP is to "provide observational meteorological data, usually consisting of daily maximum and minimum temperatures, snowfall, and 24-hour precipitation totals, required to define the climate of the United States and to help measure long-term climate changes, and to provide observational meteorological data in near real-time to support forecast, warning and other public service programs of the NWS." (National Weather Service, 2012)

COMMUNITY COLLABORATIVE RAIN HAIL AND SNOW NETWORK (COCORAHS)

CoCoRaHS is a volunteer program for monitoring daily precipitation. The program has stations primarily in the US but also has a small number of stations in Canada, with more stations planned in the future. The program has about 6000 active stations (Community Collaborative Rain, Hail and Snow Network, 2011).

CoCoRaHS focuses on low-cost measurement tools and stresses training and education. Data entry is accomplished via a web-based form (Community Collaborative Rain, Hail and Snow Network, 2011).

CITIZEN WEATHER OBSERVER PROGRAM (CWOP)

CWOP is a public-private partnership volunteer program with 3 primary goals: "To collect weather data contributed by citizens, to make these data available for weather services and homeland security; and to provide feedback to the data contributors so that they have the tools to check and improve their data quality" (Citizen Weather Observer Program, 2011).

CWOP observers send their data via internet or short-wave radio to a central server. Typically, observers send data at hourly or even more granular rates. Data are quality checked and sent to the NWS Meteorological Assimilation Data Ingest System (MADIS) where they undergo quality checks and are normalized and disseminated to data product subscribers. (Citizen Weather Observer Program, 2011)

COMPARISON --DATA QUALITY ASSURANCE AND QUALITY CONTROL

One potential problem is that the VCCN network does not have a current, established QA/QC program to ensure reliability of its data. Past records indicate that there were controls, such as regular station inspections, set up when the program was started. However, these controls are not kept up currently. Similar programs such as CoCoRaHS and NOAA's COOP network have standards and programs set up to maintain data quality and consistency within their programs.

All CoCoRaHS sites use the same standardized precipitation sampling equipment. Volunteers are trained either through an on-line or in-person course prior to joining the network. Data are published online in a timely fashion on the CoCoRaHS website to provide feedback to volunteers. (Community Collaborative Rain, Hail and Snow Network, 2011)

NOAA staff visit COOP sites at least annually and more frequently if equipment maintenance is necessary. Volunteers are required to undergo training prior to joining the program. NOAA/NWS has published standards for weather monitoring equipment location and installation. (National Weather Service, 2010). Data and information are published on the COOP website along with training and reference documents. (National Oceanic and Atmosperic Administration, Office of Climate, Water and Weather Services, 2011)

Similarly, CWOP posts a lot of information and procedural documents online which aid volunteers in siting, installing, maintaining and operating automated weather stations. Additionally, data is automatically checked for quality by MADIS prior to dissemination. One of the most important quality checks is the immediate feedback that CWOP volunteers get on the quality of their data in comparison to nearby stations. This helps volunteers to quickly find and fix problems. (Citizen Weather Observer Program, 2011)

VOLUNTEER OUTREACH AND FEEDBACK

In addition to its training information, CoCoRaHS publishes program updates and news in newsletters and blogs on the CoCoRaHS website. This helps keep volunteers informed and connected with the project. Data are published online, which provides immediate feedback to volunteers about their efforts. This network is continually accepting new members (Community Collaborative Rain, Hail and Snow Network, 2011).

COOP data are published online, which provides almost immediate feedback to participants about their participation. Annual site visits also keep volunteers in contact with the program. News and program updates are published periodically online (National Oceanic and Atmosperic Administration, Office of Climate, Water and Weather Services, 2011).

The VCCN program does not have a webpage or other regularly published source of information on the program. The data from VCCN sites is not formally published or returned to the program volunteers. There is no current program of information on site selection, equipment placement, or equipment maintenance available to volunteers and no regular schedule of site visits.

PERIOD OF RECORD

CoCoRaHS is a relatively new program. Stations have only been collecting data since 2008, and therefore the period of record for CoCoRaHS stations is not yet long enough to be very useful for flood or climate change analyses. The COOP network is older, with many sites with decades of continuous collection. COOP was officially established in 1890. CWOP, which focuses on automated monitoring by private citizens, is a relatively young network.

As noted above, the VCCN differs from many of the newer networks in that it has many sites with long periods of record. Long period of record is the feature that makes the VCCN valuable for climatology tracking and flood studies.

COVERAGE

SPATIAL COVERAGE

CoCoRaHS has about 700 active sites in California. However, most of these sites are located in high-density population centers and are not evenly distribution across the state. New members are continually being accepted.

There are about 450 Active NWS COOP Sites in California. COOP sites are well distributed spatially across the state.

As of April, 2012, there are approximately 700 active automated real-time CWOP sites in California (Citizen Weather Observer Program, 2011), and this number has grown steadily from about 500 active sites in 2010.

In comparison, the VCCN program has approximately 80 active sites statewide, and comprises only a small fraction of the many thousands of monitoring sites statewide. VCCN stations generally monitor areas that are already well represented by a combination of all other monitoring networks.

In general, there is denser coverage in the North Central region, and sparser coverage in the Northern Region. There is also denser coverage in the more populated areas and sparser coverage in the less populated areas. In general, the VCCN is well distributed spatially, and does have stations in the North and East parts of the state, in areas that are not as well covered by other networks.

A useful set of station for examining coverage in the state is DWR's Bulletin 195 Depth Duration Frequency dataset. This product has been updated regularly, and the stations used for making this product include stations from NWS COOP, most DWR networks including CIMIS, many county and local networks, and other data sources. The number of stations used for this product is over 4000. This set comprises a majority of the climate monitoring sites in California, including all the monitoring networks discussed in this report.

Figure 5 shows the locations of VCCN monitoring stations as well as the Bulletin 195 station set. As shown, overall spatial coverage (all climate data sources) is very good within the state, with an average of about one station every 3 square kilometers, though stations are more dense in the water-producing northern parts of the state, and much less dense in the Southeast deserts and valleys east of the Sierra Nevada.

ELEVATION COVERAGE

An important criterion in mountainous regions is the elevation of the monitoring station. Orographic precipitation in the western slopes of the various mountain ranges in California necessitates monitoring at different elevations to ensure adequate monitoring of precipitation. Elevation range coverage is more important than spatial coverage in mountainous regions. A higher density of stations in regions with large ranges in altitude is desirable. Generally, the mountainous regions of the state have less spatial coverage than the flatter, more populated areas.

The California Cooperative Snow Survey (CCSS) targets precipitation at different elevation ranges. Other networks provide more locations in mountainous regions. The VCCN has some monitoring locations in mountainous regions of the State that are relatively sparsely covered by other networks.

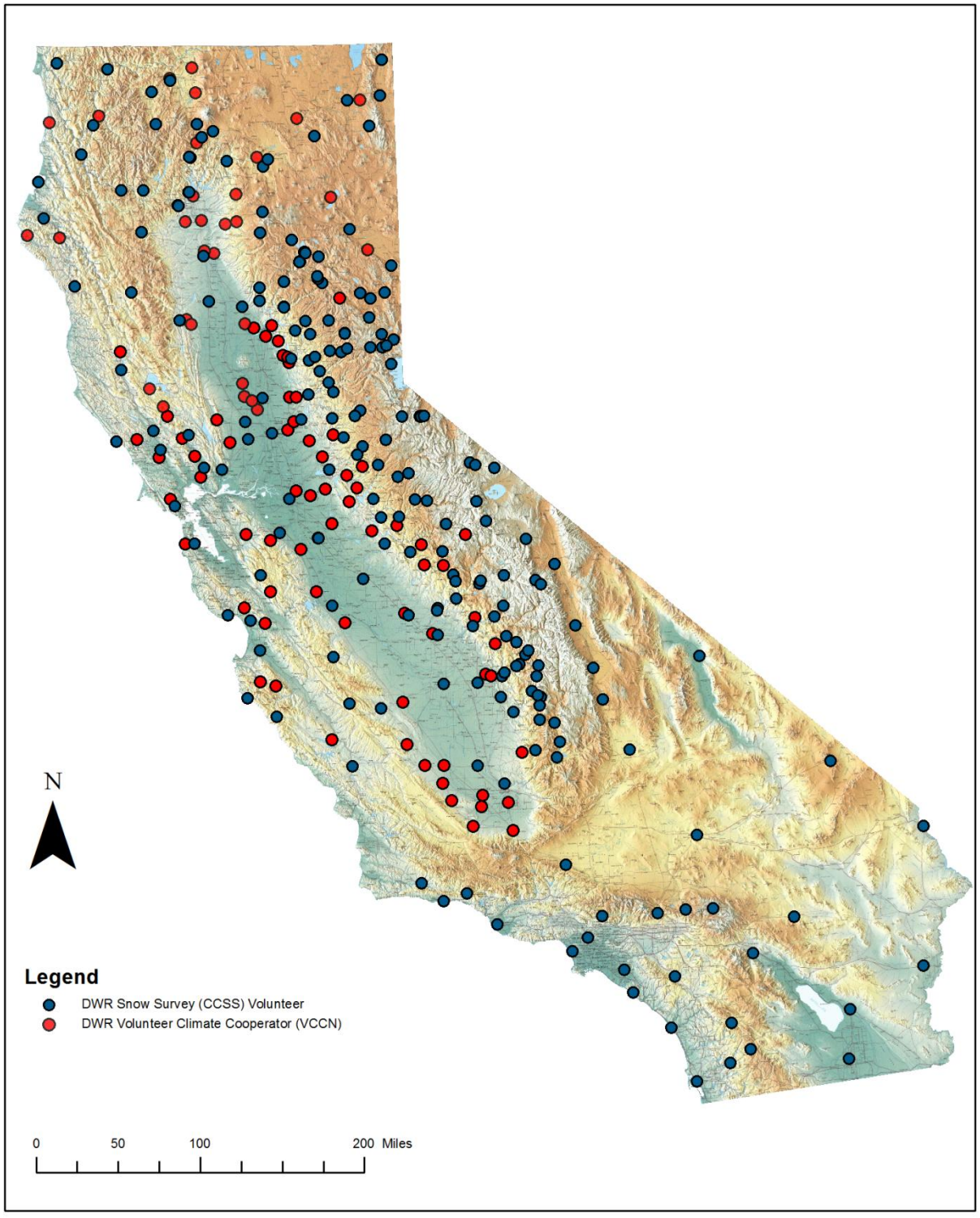


Figure 4: VCCN and DWR California Cooperative Snow Survey Networks

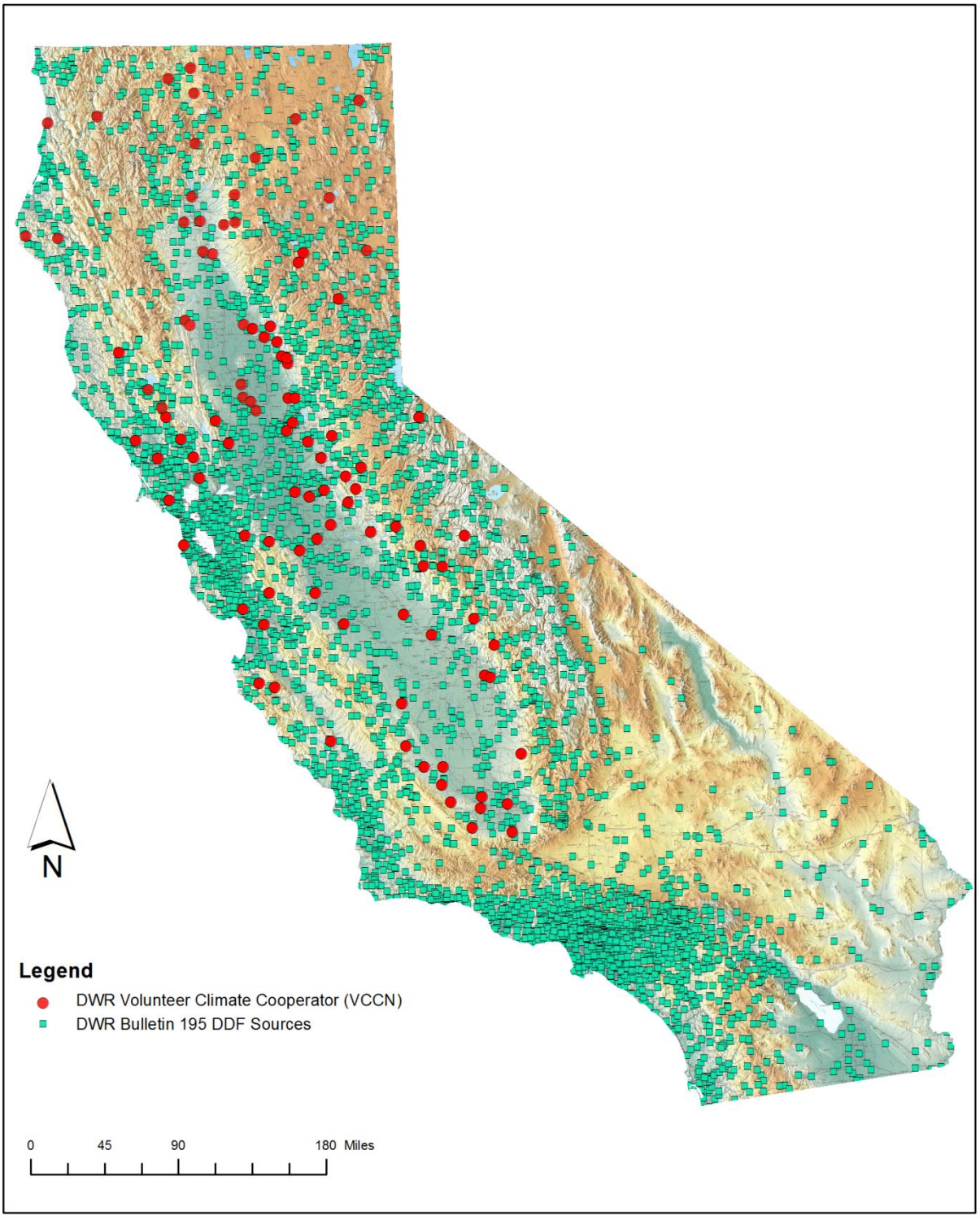


Figure 5: VCCN and DWR DDF (Bulletin 195) Stations

CONCLUSIONS

SUMMARY OF FINDINGS

DWR's VCCN has been in decline for over two decades. Monitoring stations with long-period records across the State are at risk. Presently there are about 80 volunteers left in the program.

The network does not have a coherent quality assurance program, and volunteer outreach and education has not been done adequately in the last 20 years.

Data storage and dissemination programs are inconsistent and outdated, and need work. A centralized database and web application for data entry and dissemination would be major improvements to the program.

Sites in the VCCN generally have long periods of record, and there are sites in the network that are in areas with relatively sparse spatial coverage. The network as a whole is a small but valuable part of the large set of programs monitoring climate in California.

The network does not supply novel data that isn't generally supplied by an assortment of other monitoring networks across the State. However, the program has usefulness as a supplement to the other climate data networks within the state. Its data has been and can continue to be used in Depth-Duration-Frequency data products and could be useful data particularly for climate tracking studies in the future.

The program also has potential value for outreach and education, as it could help build public awareness of climate issues.

RECOMMENDED FUTURE OF THE PROGRAM

REASONS TO CONTINUE THE PROGRAM

Monitoring stations with long-period records across the State are at risk. A plan is needed to support their continuation or to encourage the volunteers to move to other data collection networks. An additional part of the plan for future work should include archiving or assessing the value of historical climate records taken by the VCCN. Without additional support, the program will continue the downward trend it has been on for the last 20 years, resulting in the continued loss of volunteers, lack of outreach to loyal volunteers, and degradation of climate data quality and quantity.

HONOR VOLUNTEER EFFORTS

Volunteers are continuing to send data to DWR. In some cases, volunteers have continued to send data to DWR for 25 years or more without any support or feedback from DWR staff. The data is not being well utilized at present, due to outdated and inadequate archiving and dissemination. Volunteer efforts should be honored by either directing them to other networks that will support them, or rebuilding the VCCN program.

MAKE THE DATA AVAILABLE FOR USE

The data currently is not available to researchers outside DWR, and is difficult to access even for those within DWR as well. The collected data is useful for climate and flood studies, but its usefulness is currently undermined by data inaccessibility.

SUPPORT QUALITY DATA COLLECTION

Some volunteers have left the program due to lack of feedback from the department. Volunteers need regular feedback and support in order to continue quality data collection.

REASONS TO CHANGE EXISTING SCHEME

If the program is to be continued, then there are a number of issues that should be addressed. The following items should be considered as part of the program to rebuild the VCCN. Quality assurance, outreach, training, and dissemination should be part of the future of the VCCN.

ENSURE DATA QUALITY

A documented program of training, education, outreach, and data quality assurance should be implemented to ensure that data quality can be better assessed.

CoCoRaHS, COOP, and CWOP have websites and documents that explain procedures, help educate volunteers, and provide regular feedback on data. Additionally, COOP and CoCoRaHS have formal training for volunteers to help ensure quality data is collected. These networks can be models for how a viable program can be rebuilt at DWR.

CENTRALIZE THE DATA ARCHIVE

To better enable data access and dissemination, a central data archive for all VCCN volunteer data is needed. The current scheme, with each region office collecting and maintaining their own data in data silos, makes access to the data very difficult even to scientists working within DWR. Access to the data is virtually impossible for potential users outside DWR, both from an outreach standpoint (few inside and outside DWR even know we have the data) as well as an accessibility standpoint (it's hard to get, even if you know where the data is.)

There are several possible avenues for centralized archiving of the existing as well as future data. The centralized DWR database application could be completed and a web application developed to enable data entry and retrieval from all Region Offices. A prototype of this application was previously created by DSIWM Data Publication, Exchange and Management Section. This project could be completed. This would allow better access for data users and promote more timely data entry and quality assurance and control. One possible alternative to housing the data at DWR is to have the Western Region Climate Center (WRCC) archive all the raw VCCN data.

IMPROVE DATA DISSEMINATION

While intimately related to data archiving discussed above, dissemination can be considered a dependant extension of a data archive. If data are archived in-house at DWR, then a method of data dissemination should be implemented for the network.

If the data are instead housed at WRCC, then existing dissemination tools managed by WRCC will be extended to the VCCN data.

RECOMMENDED FUTURE DIRECTION - COCORAHS

CoCoRaHS is an expanding program that provides good spatial coverage throughout California. However, CoCoRaHS does not include temperature data, and has only short periods of record for sites in California at this time. CoCoRaHS is expected to continue growing, and will eventually be a very good resource for precipitation studies. Effort could be made to move VCCN reporters to CoCoRaHS, although temperature data would no longer be recorded. CoCoRaHS accepts all volunteers, so any VCCN members wanting to move to CoCoRaHS would be accommodated. It is unclear whether CoCoRaHS would be able to incorporate past data into their databases.

ESTIMATED COSTS FOR TRANSITIONING EXISTING VOLUNTEERS TO COCORAHS

Some costs would be incurred in transitioning to volunteers to CoCoRaHS. These costs can be divided into one-time costs and recurring annual costs. Figure 6 and Figure 7 detail the one-time and recurring costs to DWR for facilitating this program. As shown, transitioning to CoCoRaHS would incur about $5,550 in one-time costs, and about $4,750 per year thereafter. These annual costs are likely to come down as volunteers become familiar with the CoCoRaHS data entry online and DWR data entry assistance is reduced. Costs are based on an estimated 80 active stations. Annual costs are expected to decline over time as users take over their own data entry.

Figure 6: Estimated One-time Costs to Transition to CoCoRaHS

Category	Sub-Category	Item	Estimate Description	Unit cost	Cost
Total program costs	Corres-pondence	Mass mailing explaining transitions	15 hours	$90	$1,350
		Phone support and follow-up discussions with volunteers	20 hours	$90	$1,800
	Equipment	New, CoCoRaHS approved rain gauges to all volunteers	80 new CoCoRaHS-approved gauges	$30	$2,400
	Estimated Total one-time costs				**$5,550**

Figure 7: Estimated Annual Program Costs Facilitating CoCoRaHS Participation

	Category	Item	Estimate Description	Annual Basis	Full Cost	Annual Cost
Per Site Costs	Equipment	Rain Gauge	Replacement every 10 years	0.1	$30	$3
	Labor	Data Entry on 50% of sites	0.5 hour/year	0.00025	$180,000	$45
	Per site costs - subtotal					**$48**
Program costs not related to specific sites	Labor	Correspondenc e	20 hours	0.005	$180,000	$900
	Program costs not specific to sites - subtotal					**$900**
Estimated total annual cost for maintaining 80 sites						**$4,740**

ALTERNATIVES TO MOVING VOLUNTEERS TO THE COCORAHS NETWORK

CONTINUED IN-HOUSE MANAGEMENT

ESTIMATED COSTS OF CONTINUING THE PROGRAM IN-HOUSE

In order to continue the program, certain activities will need to be funded. Costs for continuing the program include one-time costs to reconstruct program systems and infrastructure, and annual costs to the run the program thereafter.

ONE-TIME COST ESTIMATES

One-time costs for rebuilding the program include training, setting up work flows, database and web application development and documentation. These costs are estimated at $23,490, the bulk of which would be for completing a climate database and web application. Figure 8**Error! Reference source not found.** lists the estimated one-time costs for rebuilding the program.

ANNUAL PROGRAM COST ESTIMATES

Annual costs per sites, for equipment replacement, training, correspondence, data entry and periodic site visits are estimated to total $259.50 per year per site. The majority of the costs result from labor for site visits (at a site visits every 3 years) and data entry. Additional non-site specific costs for technology management, reporting, and correspondence are estimated at $3600 per year for the program. The formula for total annual program costs is therefore:

Total annual program cost = $3600 + $259.50n,

where n = number of sites in the program.

Currently the program has an estimated 80 active sites, and the estimated annual operating cost of the program is $24,360. Figure 9 itemizes the estimated annual costs for continuing the program. Costs are based on an estimated 80 remaining active stations.

Figure 8: Estimated One-time Costs to Revitalize the VCCN Program

Category	Sub-Category	Item	Estimate Description	Hourly rate	Cost
Labor costs	Infrastructure development	Setup program workflows at region offices	15 hours	$90	$1,350
		Training	26 hours	$90	$2,340
		Database application development	180 hours	$90	$16,200
	Program Documentation	Operating procedure manuals and other program documentation	40 hours	$90	$3600
	Total one-time costs				**$23,490**

Figure 9: Estimated Annual Program Costs

	Category	Item	Estimate Description	Annual Basis	Full Cost	Annual Cost
Per Site Costs	Equipment	Rain Gauge	Replacement every 10 years	0.1	$30	$3
		Thermometer	Replacement every 10 years	0.1	$20	$2
	Labor	Site visits	Site visit every 3 years. 4 hours/ site visit	0.000667	$180,000	$120
		Data entry	1 hour/year	0.0005	$180,000	$90
		Correspondence	0.5 hours/year	0.00025	$180,000	$45
	Per site costs - subtotal					**$259.50**
Program costs not related to specific sites	Labor	Reporting	10 hours	0.005	$180,000	$900
		Database/data maintenance	20 hours	0.001	$180,000	$1,800
		Correspondence	10 hours	0.005	$180,000	$900
	Program costs not specific to sites - subtotal					**$3,600**
Estimated total annual cost for maintaining 80 sites						**$24,360**

FORMALLY END THE PROGRAM

This solution would at least provide final feedback and thank-you letters to the existing volunteers, and could address the value of the data by encouraging the volunteers to continue to collect data and report to other, more stable networks such as CoCoRaHS, CWOP (for automated sensors) or regional networks such as county networks.

The cost of formally ending the program would be the cost of sending a letter to each volunteer: an estimated $1000 in staff time conservatively to draft and send out letters to all participants and follow up on any subsequent questions.

CONTINUE WITH STATUS QUO

The department could continue to accept volunteered data for as long as volunteers continue to send it. This would not require any changes to funding or staffing. However, this solution would not address the data quality, accessibility or storage issues listed above. Volunteer efforts could be minimally honored with annual letters.

Costs for continuing the program, on an annual basis are estimated to be similar to the annual costs after revitalizing the program as detailed above: $3,600 per year. No initial costs would be incurred in this case.

OTHER RECOMMENDED ACTIONS

PROMOTE COOPERATION ACROSS PROGRAMS

Within DWR, programs collect climate data separately for their own specific purposes. Individual programs are best suited to collect the data that they need. However, there are areas of overlap, for example in the creation of standard operating procedures, equipment use procedures, and data collection techniques, and observer training materials. This supplementary information could be shared across some programs. Sharing equipment recommendations and operating procedures could increase data compatibility across programs, and drive better inter-department communication and knowledge sharing, thereby improving data quality and accessibility department-wide.

PAPER DATA CATALOG

The large sets of paper data archives at the region offices are being cataloged. Some of this data may already exist in databases, but it is possible that some of this data has never been digitized. This catalog is the first step towards determining what to do with these data. Some of the data may not yet be in digital archives, and plans may need to be made for archiving portions of the data. An assessment of the value of the data can be made after the catalog process is complete.

HIGH-PRIORITY SITES

Figure 10 shows sites that are high-value of the remaining volunteers. Sites are prioritized based on period of record, proximity to other monitoring stations, location and elevation range, and currentness of the record. Appendix A has priority sites highlighted.

It is recommended that data collection continue at these locations (either through CoCoRaHS or in-house) regardless of the future direction chosen for the overall program.

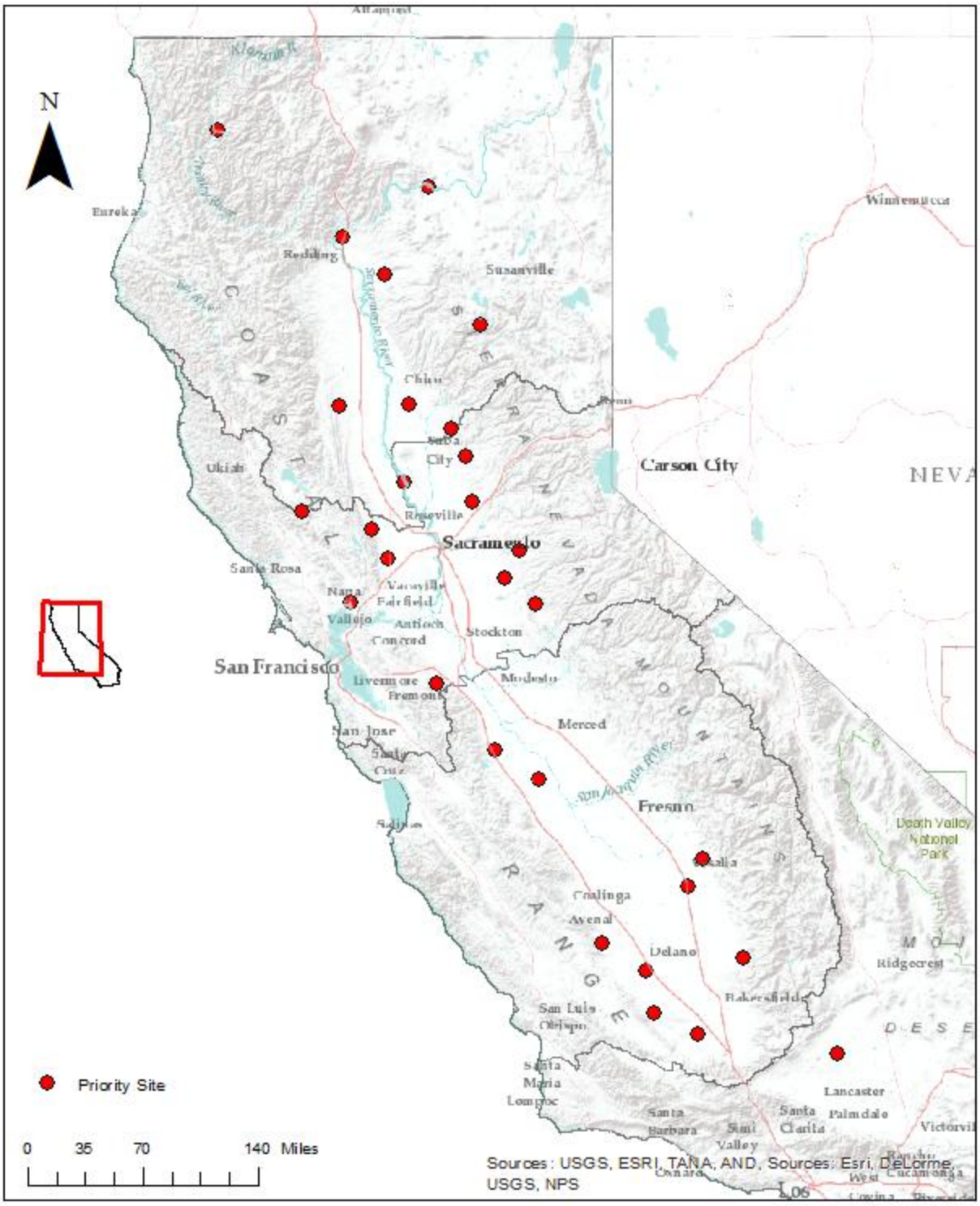


Figure 10: High-value Volunteer Sites

BIBLIOGRAPHY

California Department of Water Resources. (1976). *Bulletin 195; Rainfall Analysis for Drainage Design, Volume I: Short-Duration Precipitation Frequency Data and Volume II: Long Duration Precipitation Frequency Data.* Resources Agency, Department of Water Resources. Sacramento: State of California.

Citizen Weather Observer Program. (2011, March 11). *Citizen Weather Observer Program*. Retrieved May 2, 2012, from Citizen Weather Observer Program: www.wxqa.com

Community Collaborative Rain, Hail and Snow Network. (2011). *CoCoRaHS - Community Collaborative Rain, Hail and Snow Network*. Retrieved 10 10, 2011, from CoCoRaHS - Community Collaborative Rain, Hail and Snow Network: http://www.cocorahs.org/

County of Santa Barbara. (2012, May 2). *Rainfall Summary*. Retrieved May 2, 2012, from County of Santa Barbara Public Works: http://santabarbara.onerain.com/rain.php

Department of Water Resources, Office of Water Use Efficiency. (2009). *CIMIS Overview*. Retrieved June 6, 2012, from California Irrigation Management Information System: http://wwwcimis.water.ca.gov/cimis/welcome.jsp

Flakus, T. (2012, 2 3). Personal communication. *Personal communication* . Red Bluff.

Henderson, A. (2011). *Internal Memorandum: IRWM Regional Office Climate Data Collection Activity Summary.* California Department of Water Resources.

National Oceanic and Atmosperic Administration, Office of Climate, Water and Weather Services. (2011, August 17). *NWS Cooperative Observer Program home*. Retrieved September 19, 2011, from NWS Cooperative Observer Program : http://www.weather.gov/os/coop/index.htm

National Weather Service Modernization Committee, National Research Council. (1998). *Future of the National Weather Service Cooperative Observer Network.* National Academy of Sciences.

National Weather Service. (2010). *National Weather Service Instruction 10-1301: Aviation and Synoptic Observations.* National Weather Service.

National Weather Service. (2012, April 25). *NWS Cooperative Observer Program, What is the COOP Program?* Retrieved June 18, 2012, from NWS Cooperative Observer Program: http://www.nws.noaa.gov/om/coop/what-is-coop.html

APPENDIX A: LISTS OF ACTIVE SITES

NORTHERN REGION OFFICE

CST_ID	CST_NAME	FIRST MEAS	LAST MEAS	YEARS
31426	ANDERSON 9 WNW	11/1/1973	5/31/2011	37
31427	ANDERSON STP (AWPCP)	2/4/1975	5/31/2011	36
31462	CENTRAL VALLEY BURNS	12/1/1951	5/31/2011	59
31645	WESTERN CANAL	10/11/1961	5/31/2011	49
31928	MCARTHUR-BURNEY FALLS SP	6/10/1971	5/31/2011	40
31955	CASTLE CRAGS S P		5/31/2011	?
32054	KILARC POWER HOUSE	10/21/1989	5/31/2011	21
32076	VOLTA PH	10/21/1989	5/31/2011	21
32430	FINLEY 1 SSE	10/3/1989	5/31/2011	21
34863	BIG SPRINGS 4 E	11/6/1966	5/31/2011	44
35053	BURLINGTON ST PARK	10/21/1966	5/31/2011	44
40501	MAGALIA DAM	10/23/1991	5/31/2011	19
40502	MONTGOMERY CREEK 6N	10/22/1989	5/31/2011	21
40581	BROWN RANCH	1/7/2002	5/31/2011	9
40961	Cottonwood 3W	4/1/2003	5/31/2011	8
31479	CLARKS VALLY MUDD	1/1/1957	5/31/2011	54
31852	ALTURAS 7 ESE	10/12/1966	5/31/2011	44
34906	YREKA	4/10/2002	5/31/2011	9
34958	SOMESBAR UKONOM RS	3/1/1960	5/31/2011	51
32044	DARRAH FISH HATCHERY	7/1/1936	4/30/2011	74
35492	MILFORD	11/6/1966	4/30/2011	44
32425	COBB	10/6/1961	2/28/2011	49
31701	RED BLUFF 1N	2/14/1975	12/31/2010	35
31585	KARNAK	10/2/1989	9/30/2010	21
31586	KIRKVILLE	10/2/1989	9/30/2010	21
31723	ROBBINS	10/21/1989	9/30/2010	20
31763	TISDALE WEIR	10/10/1961	9/30/2010	49
31920	LOOKOUT SHAW	7/1/1967	9/30/2010	43
40499	MACDOEL 5W	12/5/1989	9/30/2010	20
40503	NAVARRO	10/20/1989	9/30/2010	20
40580	RENO11NW	10/26/1995	9/30/2010	14
40487	BECKWOURTH	12/11/1990	8/31/2010	19
40971	Brown Ranch	6/1/2010	6/30/2010	0
40512	SHINGLETOWN	11/6/1966	7/31/2009	42
35028	ORICK ARCATA REDWOOD	10/6/1966	10/31/2008	42
40509	RUSSIAN GULCH	12/16/1987	8/31/2008	20
31697	RED BLUFF CLARK RCH	10/11/1961	9/30/2007	46
40507	RED BLUFF 20 WSW	10/28/1977	8/31/2007	29
34957	SOMESBAR IW	2/1/2007	4/30/2007	0
34926	FOOTHILL SCHOOL	10/12/1966	11/30/2006	40
35439	EAGLE LAKE NELSON/SPAULDINGS	10/9/1962	6/30/2006	43

NORTH CENTRAL REGIONAL OFFICE ACTIVE SITES

CST_ID	CST_NAME	FIRST MEAS	LAST MEAS	YEARS
31647	NEWCASTLE FOWLER	10/1/1948	3/31/2011	62
32587	LINDEN FIRE STATION	10/1/1996	3/31/2011	14
32778	PRESTON SCHOOL	10/1/1954	3/31/2011	56
35286	GUERNEVILLE 2N(STATE PK)	10/1/1985	3/31/2011	25
39299	CARMICHAEL - WINSTON	10/1/1989	3/31/2011	21
39312	PLYMOUTH 4 NNE	10/1/1973	3/31/2011	37
39322	HENRY W. COE STATE PARK	3/1/1995	3/31/2011	16
39321	BANTA CARBONA	10/1/1994	2/28/2011	16
32117	CARIBOU PH	10/1/1985	1/31/2011	25
32416	CAPAY 4W	1898	1/31/2011	113
34123	DUTTONS LANDING	10/1/1985	1/31/2011	25
39306	FAIR OAKS JOHNSON	10/1/1984	1/31/2011	26
39310	LIGHTS RANCH UKIAH	10/1/1987	1/31/2011	23
34452	LIVERMORE SEWAGE PLT	10/1/1985	12/31/2010	25
31753	SMARTSVILLE	10/1/1952	11/30/2010	58
31818	WINTERS WOLFSKILL RCH	10/1/1937	11/30/2010	73
39298	BOTHE - NAPA STATE PARK	10/1/1985	11/30/2010	25
32788	SWISS RANCH ROAD	10/1/1990	9/30/2010	20
32209	BANGOR FIRE STATION	10/1/1985	8/31/2010	24
34160	VETERANS HOME	10/1/1985	8/31/2010	24
32784	SAN ANDREAS R S	10/1/1954	11/30/2009	55
33029	CASTLE ROCK RAD LAB	10/1/1955	11/30/2008	53
31673	PALERMO	10/1/1985	7/31/2008	22
32493	MIDDLETOWN 4 WSW	10/1/1985	6/30/2008	22
32576	JENNY LIND 35W	10/1/1959	2/29/2008	48
34763	PACIFICA VALLEMAR	10/1/1985	11/30/2007	22
35556	GROVER HOT SPRINGS	10/1/1961	5/31/2007	45
32116	CANYON DAM	5/1/1998	4/30/2007	9
32175	OROVILLE DAM	10/1/1985	4/30/2007	21
31695	RANCHO CORDOVA DANLEY	10/1/1982	3/31/2007	24
31762	THERMALITO AFTERBAY	10/1/1985	3/31/2007	21
31456	BROWNS VALLEY 3NE	6/1/2006	12/31/2006	0
32273	SIERRA FOOTHILL FIELD STA	1/1/2004	9/30/2006	2
35341	SANTA ROSA LAGUNA PLT	10/1/1968	5/31/2006	37
34044	WOODACRE	10/1/1958	4/30/2006	47

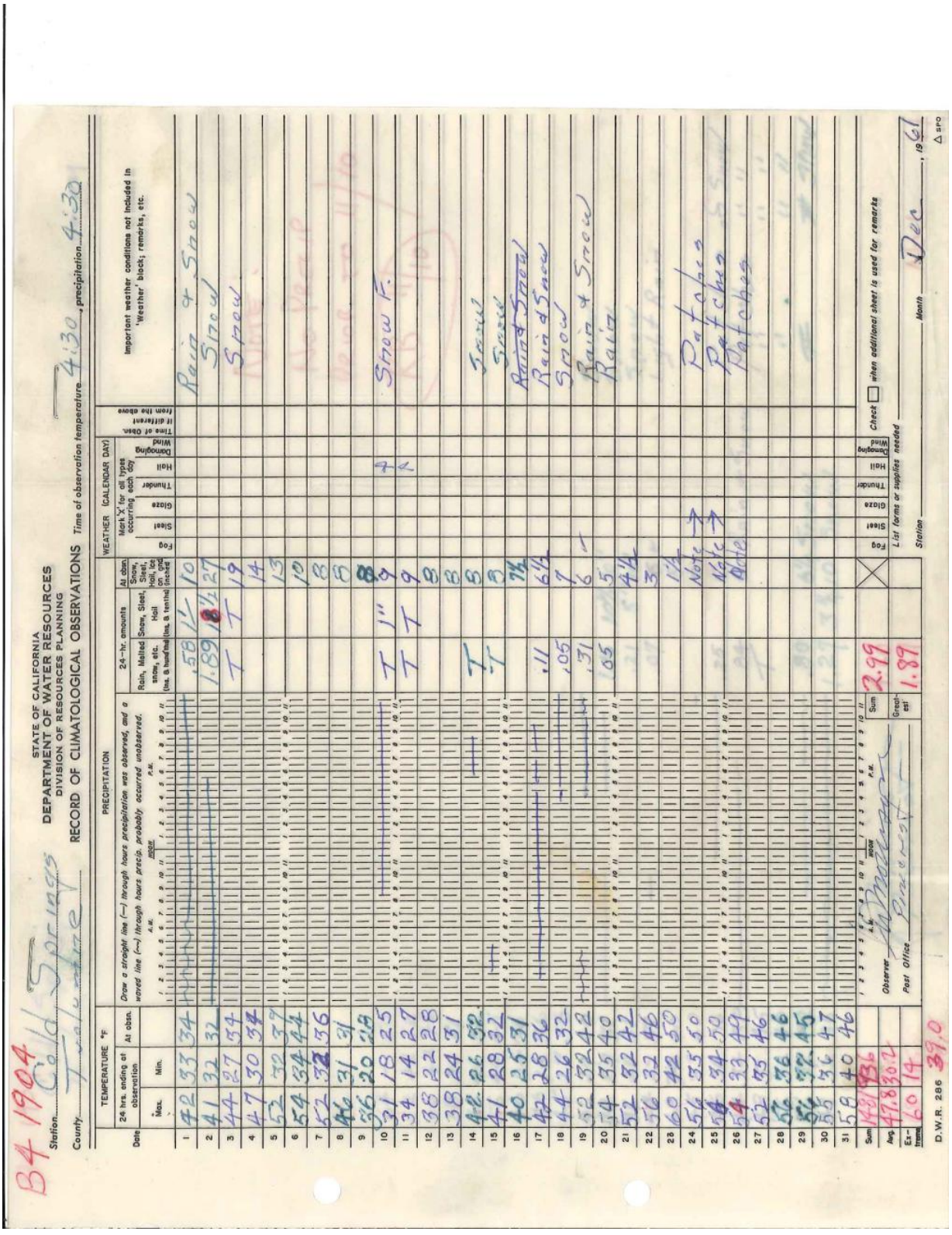
SOUTH CENTRAL REGION SITES

SiteNumber	SiteName	LastRecord	elevation	yrsRec
B00 3698 80	Gustine 7 SSW	2008	156	48
B00 5233 00	Madera	2009	268	77
B00 6303	Oakdale (AL Gilbeit Co)	2009		
B00 8378 00	South Dos Palos	2008	116	66
B40 2473 00	Don Pedro Dam	2009	823	61
B60 7276 00	Raymond 12 NNE	2008	1600	42
	Big Oak Flat Entrance	2009		
C01172	BUENA VIST PUMPING PLANT 4	2008		
C00 0399 00	Avenal Orchard Ranch	2008	712	44
C00 1174 00	Buena Vista Ranch	2008	310	85
C01972	CONNER 35E (TIME ROOM)	2008		
C00 3428 01	Gin Yard	2008	295	42
C0 4188 00	Huron Ranch [Huron Woolf]	2008		
C00 4312 05	Ivanhoe	2008	6370	33
C00 5151 30	Lost Hills DWR	2009	312	48
C00 8876 01	Terra Bella	2008		
C00 9051 00	Tulare ID	2008	293	36
C00 9499 50	Weed Patch 8 SW	2008	390	18
C00 9724 60	Wind Gap	2009	814	29
C40 9805 00	Woody	2008	1630	45
C70 5338 01	Maricopa FS	2008	885	49
C70 5480 01	McKittrick FS	2008	1051	57
D20 6650 00	Paloma	2008	1835	49
	North Kern Water Storage	2008		
B00 7447 80	Ripon	2007	65	34
B00 9565 00	Westly	2005	85	54
B40 4015 00	Hodgon Meadow	2007	4640	35
B50 4369 00	Jerseydale	2007	3605	38
B60 0544 50	Batterson	2007	3100	29
B60 0544 50	Daulton	2007	3100	29
B70 5893 00	Mountain Rest	2007	4100	13
B70 6252 00	North Fork RS	2007	2630	78
B80 6583 00	Pacheco Pass	2007	1320	33
	Buena Vista Ranch M&L 2	2007		
C00 2355 50	Del Kern Station	2006	345	22
C10 9025 00	Trimmer	2007	1540	55
C20 5708 00	Miramonte HC	2007	3005	48
D10 1247 00	Buzzard Lagoon	2006	1275	41
D10 1729 01	Chittenden	2007	104	61
D30 3722 00	Hames Valley	2006	725	29

D40 5143 00	Los Padres Dam	2007	900	55
D40 6587 60	Pacific Grove Reservoir	2007		
D40 7731 00	San Clemente Dam	2007	600	86
	Fence MDW	2007		
	North Kern	2007		

Highlighted Sites are considered highest-value.

APPENDIX B: EXAMPLE OF A HISTORICAL VCCN DATA SHEET



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
RECORD OF CLIMATOLOGICAL OBSERVATIONS

B4 1904
Station Cold Springs
County Tuolumne

Time of observation temperature 4:30 precipitation 4:30

Date	TEMPERATURE °F 24 hrs. ending at observation Max.	Min.	At obsn.	PRECIPITATION Draw a straight line (—) through hours precipitation was observed, and a waved line (~) through hours precip. probably occurred unobserved. A.M. / 1 2 3 4 5 6 7 8 9 10 11 NOON / 1 2 3 4 5 6 7 8 9 10 11 P.M.	24-hr. amounts Rain, Melted snow, etc. (Use 0, hundredths)	Snow, Sleet, Hail (Use 0, tenths)	At obsn. Snow, Sleet, Hail, ice on grnd (inches)	WEATHER (CALENDAR DAY) Mark 'X' for all types occurring each day: Fog	Sleet	Glaze	Thunder	Hail	Damaging Wind	Time of Obsn. if different from the above	Important weather conditions not included in 'Weather' block; remarks, etc.
1	42	33	34		.58	1.5	10									Rain + Snow
2	41	32	32		1.89	18½	27									Snow
3	44	27	34		T	T	12									Snow
4	47	30	37				14									
5	52	30	37				13									
6	54	34	44				10									
7	52	32	36				8									
8	46	31	31				8									
9	36	20	25				8									
10	31	18	25		T	1"	9									Snow F.
11	34	14	27		T	T	9									
12	38	22	28				8									
13	38	24	31				8									
14	42	26	32		T		5									Sleet
15	41	28	32		T		8									Sleet
16	40	25	31				7½									Rain & Sleet
17	42	28	36		.11		6½									Rain & Sleet
18	44	26	32		.05		4									Snow
19	52	32	42		.31		6									Rain + Snow
20	54	35	40		.05		5									Rain
21	52	32	42				4½									
22	56	32	46				3									
23	60	42	50				1½									
24	56	35	50				Note →									Patches
25	54	34	50													
26	54	33	49				None →									Patches
27	52	35	46													
28	52	36	46				Note									
29	52	32	45													
30	56	36	47													
31	59	40	46													
Sum	1478	936			Sum 2.99											
Avg	47.8	30.2		Observer A. McGregor	Greatest 1.89											
Extreme	60	14		Post Office Brassie												

Fog | Sleet | Glaze | Thunder | Hail | Damaging Wind

List forms or supplies needed _____ Station _____

Check ☐ when additional sheet is used for remarks

Month Dec 19 61

D.W.R. 286 39.0

△ SPO

APPENDIX C: BLANK CLIMATOLOGY DATA COLLECTION FORM

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

RECORD OF EVAPORATION AND CLIMATOLOGICAL OBSERVATIONS

Station_____ County_____ Month_____, 19____

Time of Observation_____ Observer_____

Date	AIR TEMPERATURE °F								WATER TEMP. °F		PRECIPITATION			WIND		EVAPORATION (Inches & hundredths)			ADDITIONAL DATA— REMARKS
	24 Hrs. Ending at Obsn.		At Observation			Supplemental Readings at_____			24 Hours Ending at Obsn.		24 Hr. Amounts		At Obsn.	Anemometer Dial Reading (Miles)	24 Hr. Movement	Gage Reading or Amount Added +	Reading When Tank Filled or Amount Removed −	Amount of Evaporation	
	Max.	Min.	Dry-bulb	Wet-bulb	Dew Point	Dry-bulb	Wet-bulb	Dew Point	Max.	Min.	Rain, Melted Snow, etc. (Inc. & hund'ths)	Snow, Sleet, Hail (Ins. & tenths)	Snow, Sleet, Hail on gnd. (Inches)						
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			
15																			
16																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
26																			
27																			
28																			
29																			
30																			
31																			
Sum.																			
Avg.																Adjusted Total			

REMARKS.....